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2-12-1968

Service Propulsion System (SPS) - Malfunction Symptoms 1 - 10 and hand drawn diagrams

National Aeronautics and Space Administration (NASA)

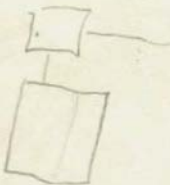
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SPS
UPDATE



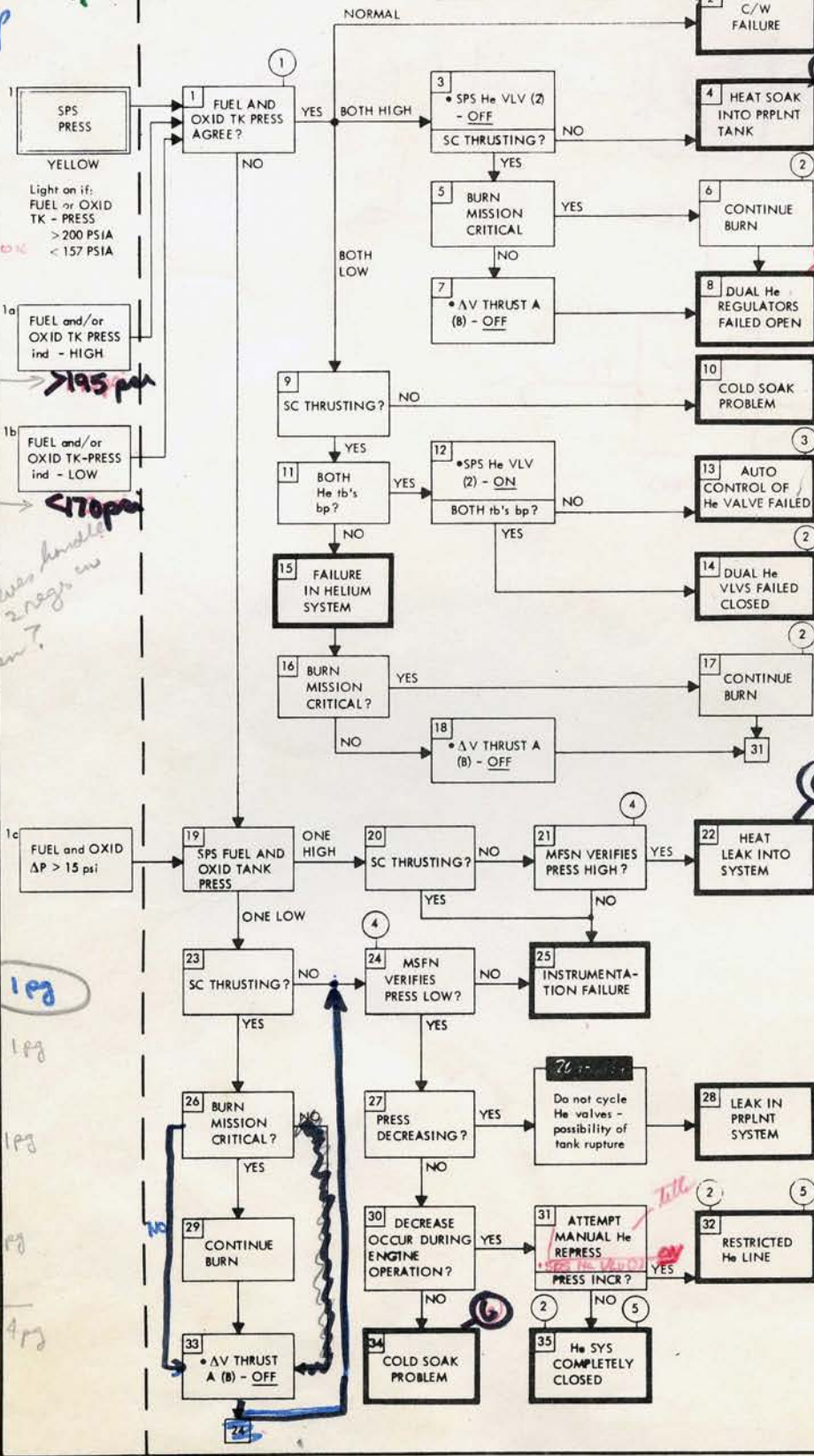
3 additional flows
needed!
(see back)

SM2A-03-SC101-(2)
APOLLO OPERATIONS HANDBOOK

SYMPTOM

PROCEDURE

REMARKS



1 Normal operating pressure is 170-195 psia. MSFN will use Fuel and Oxid telemetered pressure data to backup onboard indications.

2 ~~SPS He VLV (2) - OFF~~
Engine chugging may occur. if SPS P<70
NAA

3 Manual He valve control required.
Control PROP TANK PRESS between 115 & 185 psi by manual actuation of He switch.

4 Caution - ΔP between FUEL and OXID TK - PRESS should not exceed 15 PSI during a burn. Degraded performance, rough combustion, and/or engine failure may result.

5 All subsequent SPS burns should be made with SPS He VLV sw (2) - OFF to minimize ΔP between fuel and oxidizer.

6 Attempt temperature control by reselecting spacecraft if possible

SPS MALFUNCTION

update 2-12-68
ant Red
Final review 4/17/68
Walt - see 195-195 this is close 200 C/W
reduced to 4 pp (from 5)

question - how does pressure handle He flow with 2 reg's in series?

Peac
1 - 1
2 - 106
3 - 22
4 - 103
5 - 22
6 - 32
7 - 22
8 - 122
9 - 32
10 - 42

4 pp

premature
eng
Shutdown

Rough
ECO
ON?

NO

Mod
Cme

YES

NO

YES

Rough
ECO

burn
miso
out

YES

NO



SM2A-03-SC101-(2)
APOLLO OPERATIONS HANDBOOK

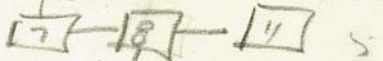
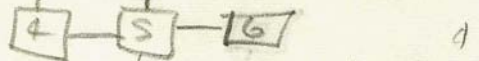
| SYMPTOM | PROCEDURE | REMARKS |
|---|--|--|
| <p>2 SPS ROUGH ECO</p> <p>YELLOW</p> <p>Light on if: Vibration level of 180 g's peak-to-peak for 70 ± 20 msec, or 360 g's peak-to-peak for 30 - 70 msec</p> | <p>1 BURN MISSION CRITICAL?</p> <p>YES → 2 • FCSM (2) - RESET/OVERRIDE • FCSM (2) - on(up) SC CONTROL MODE? → 3 • +X TRANSLATION OR DIRECT ULLAGE • THRUST ON pb - push</p> <p>NO → 4 RESET/OVERRIDE has restarted engine. Interruption of engine on command occurs during switching transition! → 5 SPS ROUGH ECO If ON?</p> <p>5 YES → 6 TRANSIENT VIBRATION LEVEL SENSED IN SPS ENGINE → 7 EXCESSIVE ENGINE VIBRATION DUE TO COMBUSTION INSTABILITY → 8 • FCSM (2) - RESET/OVERRIDE SC CONT MODE? → 9 • +X TRANSLATION OR DIRECT ULLAGE • THRUST ON pb - push → 10 CONTINUE NORMAL PROCEDURES</p> <p>5 NO → 11 AUTOMATIC RESTART OF ENGINE AND CONTINUATION OF THRUSTING SEQUENCE</p> <p>12 • ΔV THRUST A (B) - OFF ROUGH ECO ON? → YES → 13 C/W FAILURE → 14 POSSIBLE COMBUSTION INSTABILITY OR INSTRUMENTATION FAILURE → 15 EXCESSIVE ENGINE VIBRATION DUE TO COMBUSTION INSTABILITY → 16 SPS COMBUSTION INSTABILITY → 17 SPS COMBUSTION INSTABILITY</p> <p>12 NO → 14 MSFN VERIFIES SPS ABNORMAL OPERATION? → YES → 16 SPS COMBUSTION INSTABILITY → 17 SPS COMBUSTION INSTABILITY</p> <p>12 NO → 14 MSFN VERIFIES SPS ABNORMAL OPERATION? → NO → 15 POSSIBLE COMBUSTION INSTABILITY OR INSTRUMENTATION FAILURE → 16 SPS COMBUSTION INSTABILITY → 17 SPS COMBUSTION INSTABILITY</p> | <p>1 SPS ROUGH ECO light will go out when FCSM circuitry is reset. The SPS THRUST SW in DIRECT ON Position also overrides the FCSM monitors.</p> <p>2 If in G/N AV, automatic restart of the engine will occur if < 3 - 4 sec has elapsed since shut-down. If > 4 sec, V50 N99 will flash and ENTR must be pushed within 10 sec for automatic restart.</p> <p>3 SPS ROUGH ECO light, is reset when AV THRUST - A and B switches are OFF.</p> <p>4 SPS is fully operable but ROUGH ECO light will remain on for duration of mission.</p> <p>5 SPS operable but FCSM may terminate subsequent burns.</p> <p>6 SPS operability dependent upon subsequent investigation.</p> |
| <p>3 SPS FLANGE TEMP HI</p> <p>YELLOW</p> <p>Light on if: Injector/chamber Flange temp is ≥ 480°F</p> | <p>1 BURN MISSION CRITICAL? → YES → 2 CONTINUE BURN → 3 C/W FAILURE</p> <p>1 NO → 4 IF THRUSTING • ΔV THRUST A (B) - OFF → 5 MSFN FLANGE TEMP READOUT? → 6 BOTH HIGH → 7 EXCESS FLANGE TEMP → 8 EXCESS FLANGE HEATING OR INSTRUMENTATION FAILURE</p> <p>5 BOTH NORMAL → 3 C/W FAILURE</p> <p>5 ONE HIGH ONE NORMAL → 7 EXCESS FLANGE HEATING OR INSTRUMENTATION FAILURE</p> | <p>1 High flange temp may occur up to 10 minutes following a burn from normal heat soak-back.</p> <p>2 Flange burn through may be expected at anytime, possible resulting in chamber separation.</p> <p>3 MSFN can confirm flange temperature over 480°F.</p> |

SPS
MALFUNCTION

30 min

leave as is

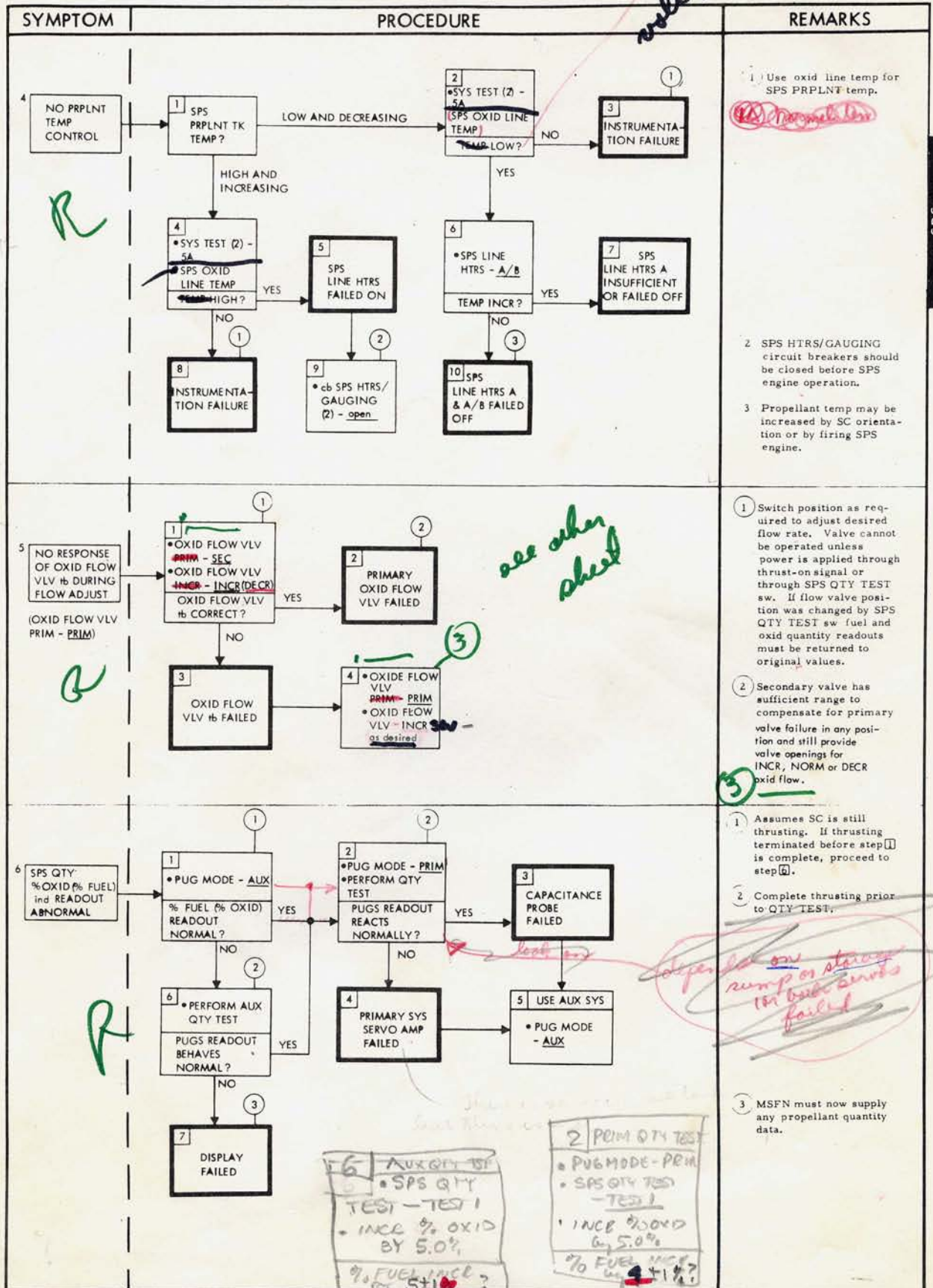
discrepancy between this and possible by MSFN a readout of actual flange temp and valve temp and nozzle temp.



perhaps
additional steps
required

SM2A-03-SC101-(2)
APOLLO OPERATIONS HANDBOOK

small amount of fuel on floor in SC



SPS
MALFUNCTION

see other sheet

depends on storage ramp or storage tank level sensors failed

6 AUX QTY TEST
• SPS QTY TEST - TEST 1
• INCR % OXID BY 5.0%
% FUEL INCR? 5.1%

2 PRIM QTY TEST
• PUG MODE - PRIM
• SPS QTY TEST - TEST 1
• INCR % OXID BY 5.0%
% FUEL INCR? 5.1%

SM2A-03-SC101-(2)
APOLLO OPERATIONS HANDBOOK

| SYMPTOM | PROCEDURE | REMARKS |
|---|--|---|
| <p>7 SPS QTY OXID UNBAL ind ERRATIC OR PEGGED</p> | <p>1 PUG MODE - AUX OXID UNBAL ind NORMAL?</p> <p>2 PRIMARY UNBALANCE SYSTEM FAILED</p> <p>3 PERFORM AUX QTY TEST OXID UNBAL ind NORMAL?</p> <p>4 PRIMARY UNBALANCE SYSTEM FAILED</p> <p>5 OXID UNBALANCE FAILED</p> <p>6 RETURN TO NORMAL PUG MODE • PUG MODE - PRIM • PERFORM QTY TEST • PUG MODE - NORM</p> | <p>1 Assumes quantity indicating system normal.</p> <p>2 Assumes SC is still thrusting. If thrust has terminated, proceed with step 3.</p> <p>3 If thrusting terminated before step 1 was completed, the AUX sensing system can be checked during the next SPS burn.</p> <p>4 Actuation of SPS QTY TEST switch here will realign digital display to primary system.</p> |
| <p>8 HELIUM TANK PRESSURE LOW OR DECREASING</p> | <p>1 MSFN VERIFIES SPS He TANK PRESS LOW OR DECREASING?</p> <p>2 LEAK IN HELIUM SUPPLY</p> <p>3 HELIUM INSTRUMENTATION FAILURE</p> | <p>1 MSFN will monitor redundant helium pressure instrumentation.</p> <p>2 Helium depletion imminent.</p> <p>3 SPS engine operable until engine indications require shutdown. Eng changes may occur if SPS Pc < 70 psi.</p> |
| <p>9 SPS He VLV tb ABNORMAL</p> | <p>1 SC THRUSTING?</p> <p>2 SPS He VLV 1 (2) - ON tb's gray?</p> <p>3 SPS FUEL & OXID PRESS DECREASING</p> <p>4 BOTH He VLVs FAILED CLOSED</p> <p>5 SPS He VLV 1 (2) - OFF tb's bp?</p> <p>6 He AUTO MODE MALFUNCTION</p> <p>7 tb OR ONE He VLV FAILURE</p> | <p>1 SPS engine operable until Pc reaches TBD or until engine indications require shutdown.</p> <p>2 Control PROP TANK PRESS below 175 and 185 psi by manual actuation of He Valves.</p> |

SPS
MALFUNCTION

SM2A-03-SC101-(2)
APOLLO OPERATIONS HANDBOOK

| SYMPTOM | PROCEDURE | REMARKS |
|---|---|--|
| <p>10 SPS ENG INJ VLV ind ABNORMAL</p> <p>One open during non-thrusting</p> <p>One or two closed during burn period (or burn attempt)</p> <p><i>R</i></p> | <pre> graph TD 10[10 SPS ENG INJ VLV ind ABNORMAL] --> 1[1 SPS THRUSTING] 1 -- YES --> 2[2 DOUBLE OR SINGLE BANK OPERATION?] 1 -- NO --> 7[7 MFSN VERIFIES VLV OPEN] 2 -- DOUBLE --> 3[3 CONTINUE BURN MFSN VERIFIES VALVE CLOSED?] 2 -- SINGLE --> 6[6 INSTRUMENTATION FAILURE] 3 -- YES --> 4[4 ONE SET OF BALL VALVES FAILED CLOSED] 3 -- NO --> 5[5 INSTRUMENTATION FAILURE] 7 -- YES --> 8[8 ONE SET OF BALL VALVES FAILED OPEN] 7 -- NO --> 9[9 INSTRUMENTATION FAILURE] </pre> <p><i>① PAIR</i> 4 ONE SET OF BALL VALVES FAILED CLOSED</p> <p><i>①</i> 8 ONE SET OF BALL VALVES FAILED OPEN</p> <p><i>②</i> 10 - ΔV thrust A(S) - OFF</p> | <p>① SPS fully operable on redundant bank if one bank failed.</p> <p><i>② Future ΔV's should use unaffected bank of ball valves.</i></p> <p><i>③ Failed bank should not be used except in an emergency</i></p> |

SPS
MALFUNCTION

SM-2A-1463

RCS - Ralph Tauber
SPS - Neil Townsend

Subsys Mgr
Subsys Mgr.

19th of Jan memo for 5th Feb mtg.
8 or 9 Feb phone call

SPS Symptoms needed

- 1) Abnormal SPS Pc
- 2) Premature engine Shutdown
- 3) ~~Low~~ GN₂ pres low.

prime crew
operation needed.

No.

MSC ROUTING SLIP

ASTRONAUT OFFICE

Due Date

| Circulate | Coordination | File | Read | Necessary Action | Note and Return | See Me | Signature | Comply |
|-----------|--------------|------|------|------------------|-----------------|--------|-----------|--------|
|-----------|--------------|------|------|------------------|-----------------|--------|-----------|--------|

Name or Title

Initial

Date

Name or Title

Initial

Date

A. Shepard

V. Grissom

J. Peterson

F. Haise

E. Aldrin

J. Irwin

W. Anders

J. Kerwin

N. Armstrong

D. Lind

A. Bean

J. Lousma

F. Borman

J. Lovell

V. Brand

T. Mattingly

J. Bull

B. McCandless

S. Carpenter

J. McDivitt

G. Carr

C. Michel

E. Cernan

E. Mitchell

R. Chaffee

W. Pogue

M. Collins

S. Roosa

C. Conrad

H. Schmitt

G. Cooper

W. Schirra

W. Cunningham

R. Schweickart

C. Duke

D. Scott

D. Elsele

T. Stafford

J. Engle

J. Swigert

R. Evans

P. Weitz

O. Garriott

E. White

E. Gibson

C. Williams

E. Glens

A. Worden

R. Gordon

J. Young

HERE ARE SOME ADDITIONAL SPS PROCEDURES
 THAT WERE GENERATED AT OUR REQUEST.
 AT FIRST GLANCE, THERE ARE SOME CHANGES
 THAT ARE NEEDED. (SEE MY VERSION AT END)
 COULD I PLEASE HAVE YOUR SUGGESTIONS
 BY 3/30/68 TO USE AT NAA THE FOLLOWING WEEK
 JACK

From

Phone

Date

[illegible]

APOLLO OPERATIONS HANDBOOK

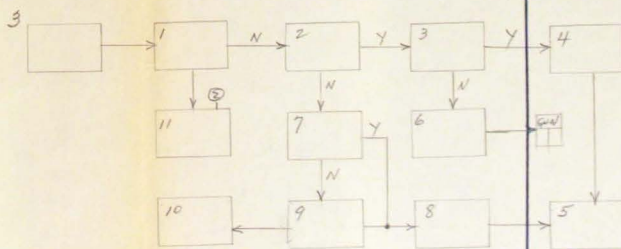
| SYMPTOM | PROCEDURE | REMARKS |
|---|--|---|
| <p>3 SPS ENG DOES NOT SHUT DOWN</p> <p><i>Why? This is not a shutdown case! Power to the engine SPS thrust light</i></p> <p><i>Please explain</i></p> | <p>1 MANUALLY C/O • AV THRUST (2) OFF</p> <p>2 CMC BURN?</p> <p>3 CMC OUTPUT CHAN • VOINICE 1ex A of R1?</p> <p>4 CMC OUTPUT CHAN FAILED</p> <p>5 USE ALTERNATE TEST FOR AV'S ON • AV THRUST-LS AT T14</p> <p>6 CMC INTERNAL PROBLEM</p> <p>7 EAS AV and < 0?</p> <p>8 SPS THRUST ON CRT IN AV COUNTER OR SES LOGIC FAILED</p> <p>9 EAS AV TEST • PERFORM EAS AV TEST SPS THRUST IF remains on?</p> <p>10 EAS ACCELEROMETER FAILED</p> <p>11 SPS ENG IN VLV GROUNDING CIRCUIT SHORT</p> <p>12 SPS ENG IN VLV GROUNDING CIRCUIT SHORT</p> | <p>① Subsequent AV's should be performed on unaffected bank (failed bank can be determined by MSFN from T14 and by crew from SPS ILS valve and display.) Failed bank may be used in emergency by placing associated AV thrust switch ON at T14.</p> |

[Handwritten scribble]

and about status of the system to determine which of the two banks is still good. The engine which is still good should be used. The engine which is still good should be used. The engine which is still good should be used.

Crew may also see it on their display panel getting engine 8.

MSFN can verify which bank of bell valves didn't close. C.B. or that system only should be pulled for remainder of mission. A note should say that subsequent burns may be performed normally on remaining good system. Affected system may be used in emergency by placing AV thrust switch on at T14.



G&N MALFUNCTION
SCS MALFUNCTION
SPS MALFUNCTION
RCS MALFUNCTION
EPS MALFUNCTION
T/C MALFUNCTION
ECS MALFUNCTION
SEQ MALFUNCTION

ROUGH DRAFT

APOLLO OPERATIONS HANDBOOK

| SYMPTOM | PROCEDURE | REMARKS |
|---------------------------------------|---|--|
| SPS ENG DOES NOT SHUTDOWN | <p>1 Manual Shutdown • AV THRUST (2) - OFF • FCSM (2) - RESET/OVERRIDE • SPS THRUST, IE still ON?</p> <p>2 CMC BURN?</p> <p>3 CMC Output Channel check • VOLTAGE IIE 1, 5 in A or R?</p> <p>4 CMC INTERNAL PROBLEM</p> <p>5 SPS ENG INJ VALV GROUNDING CIRCUIT SHORTED</p> <p>6 SPS THRUST ON CIRCUITRY (INAV COUNTER) FAILED</p> <p>7 CMC OUTPUT CHAN FAILED</p> <p>8 Use alternate system for future AVs or • AV THRUST sw ON at T IGN</p> <p>9 G&N SSK 1 CMC SELF TEST</p> | <p>① Use unaffected AV Thrust Switch for AVs - as determined by MSFN or observation of SPS ENG INJ VALV indicator</p> |
| GN2 A (B) PRESS LOW < 350 PSI | <p>1 Ind Check • SPS PRESS IND SW - N2A, N2B, He Pressure Normal?</p> <p>2 INDICATOR FAILED</p> <p>3 GN2 A (B) LEAK or FAILED SENSOR</p> <p>4 Operate Engine on alternate bank</p> | <p>① Operation at < 350 PSI results in partially open ball valves and hazardous engine operation</p> <p>Do not return to normal operation in this mode. Do not be able to get the engine</p> |
| SPS PC ABNORMAL Limits? > 110 < 90 | <p>1 SPS PRELIM F&R OXID TK PRESS NORMAL?</p> <p>2 BURN MISSION CRITICAL?</p> <p>3 AV THRUST (2) - OFF</p> <p>4 Continue Burn SPS ENG INJ VALV incl - One or two partially closed?</p> <p>5 MSFN verifies normal acceleration and system parameters?</p> <p>6 INSTRUMENTATION FAILURE</p> <p>7 He INGESTION, INTERNAL ENGINE FAILURE, OR CLOGGED PROPELLANT LINE</p> <p>8 VALVE BANK FAILED</p> <p>9 AV THRUST (failed bank) OFF</p> | <p>① Mission critical burns assumed to be dual bank</p> <p>② Failed bank should not be used except in an emergency</p> <p>③ Subsequent use of SPS engine contingent upon MSFN investigation</p> <p>④ SPS engine operation test</p> <p>depends on SPS PC reading? doesn't it? what PC blow which you would say SPS and bank?</p> <p>no! not for internal Eng. problems - Engine operation with return to 70 PSI applied to known He or gaseous tank press problem -</p> |

G&N MALFUNCTION

SCS MALFUNCTION

SPS MALFUNCTION

RCS MALFUNCTION

EPS MALFUNCTION

T/C MALFUNCTION

ECS MALFUNCTION

SEQ MALFUNCTION